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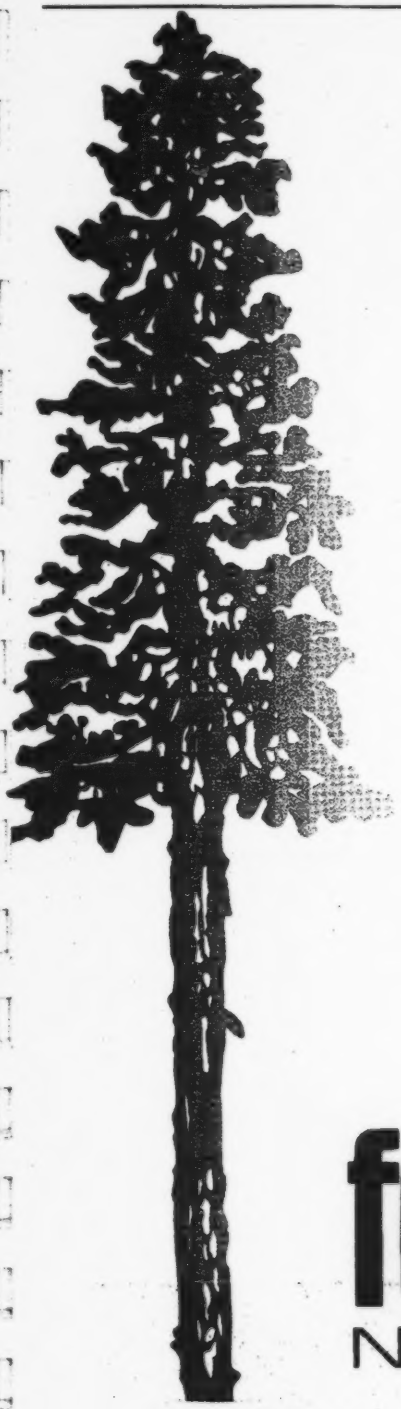

SOIL TEXTURE

and

CALIBRATION

G.Davis, MSc., PAg.

Technical Report TR-002

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Forest Sciences Section
Ministry of Forests
518 Lake Street
Nelson, B.C.
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May, 1993

SOIL TEXTURE & CALIBRATION

ABSTRACT

Periodic calibration of field soil textures will ensure consistency among field practitioners. This can be achieved by using sieves in the field and by referencing a local soil texture library. In most cases, hand textures, if done with care, will agree with laboratory determined textures. In situations where discrepancies arise, potential sources of variation should be reviewed.

Appendix I lists suppliers of sieves, screens, and laboratory analyses. For further information on the suppliers or laboratory methods contact G. Davis, Forest Sciences Section, Nelson Forest Region, at 354-6707.

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1.0 INTRODUCTION

Soil texture is an important factor influencing site productivity. It is a basic soil property that influences ecosystem characteristics such as moisture and temperature regimes, soil aeration, and nutrient availability. Soil texture also influences many of the physical properties governing soil trafficability, compactibility, erodibility, permeability, and slope stability. Because of its importance, soil texture is a key factor in the B.C. Forest Service's site disturbance hazard keys on compaction, erosion, soil displacement, mass wasting and forest floor displacement (Site Sens. IWG 1993). These are reference tools used in developing a Pre-Harvest Silviculture Prescription (PHSP).

By definition, soil texture defines the particle size distribution of the soil's mineral, or solid, fraction. This solid fraction often represents 40-60% of the "soil" volume, with voids filled with either air or water and cementing agents (e.g., organic matter, carbonates) occupying the remaining volume. By convention, the solid fraction is divided into "coarse" and "fine" particles, separated at a diameter of 2 mm.

Like all field measurements, soil texturing requires calibration, if not at each site, at least periodically throughout the field season. Foresters use soil texture as a standard to communicate information about a particular soil's properties. Because hand texturing involves some artistic interpretation, calibration is particularly important to ensure measurement consistency between field staff and, therefore, interpretations. This paper briefly reviews soil texture and its calibration, to ensure a "Rembrandt" is not mistaken for a "Picasso".

2.0 COARSE FRACTION

The coarse fraction is classified into three major size groups based on:

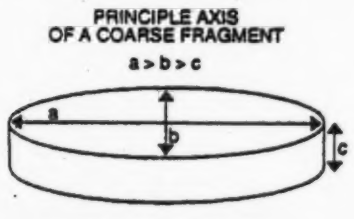
- dominant fragment type (i.e., rounded (R), subrounded (S), angular (A),and thin (T)) (Table 1) and
- fragment diameter.

Coarse fragment content is reported as a percent of the total soil volume (e.g., 25% gravel). Depending upon the dominant fragment type, soils with coarse fragments occupying 20-50% of the soil volume are classified as gravelly, cobbly, or stoney, while those with coarse fragments occupying >50% of the soil volume are classified as very gravelly, cobbly or stoney.

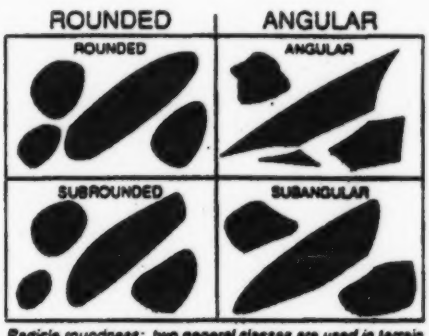
Table 1

Size Class	Types R,S,A: particle diameter	Type T: particle diameter
Gravel	<7.5 cm	< 15 cm
Cobbles	7.5-25 cm	15 - 38 cm
Stones	>25cm	> 38 cm

Fragment Chart (adapted from Luttmerding et al. 1990)



coarse fragment size is always determined along the b-axis



Particle roundness: two general classes are used in terrain mapping (rounded in angular).

2.1 CALIBRATION: Coarse Fraction

Coarse fragment content (%) is determined in the field based on a visual estimate of the volume of soil occupied by coarse fragments. Available field tools include:

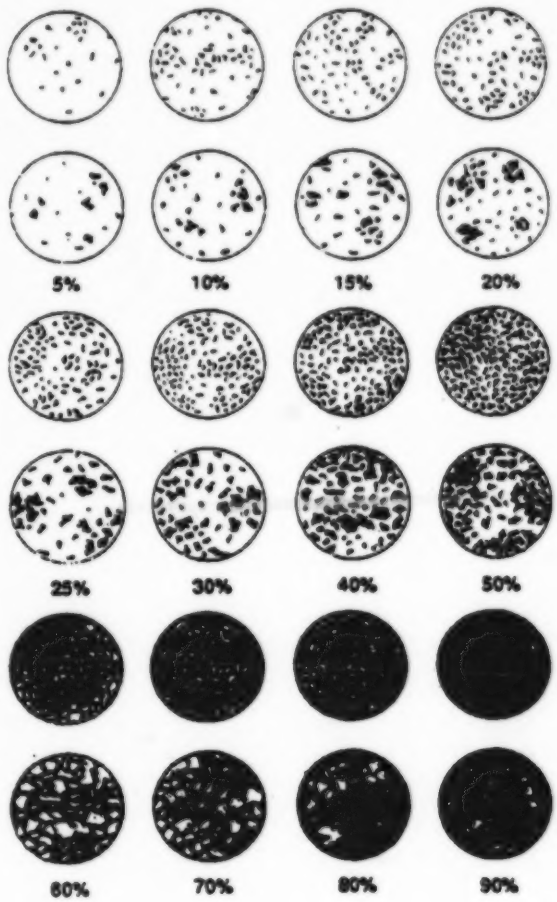
- fragment size chart (Mitchell et al. 1993) (Table 1).
- comparison charts for visual estimation of coarse fragments (Mitchell et al. 1993) (Figure 1);

These visual estimates of coarse fraction volumes require periodic field checks/calibration. The visual coarse fragment estimate (%) should be calibrated using a sieve. A representative sample of each soil layer should be sieved through 2 mm (No. 10) and 75 mm (3") sieves. Since it is impractical (if not impossible) to sieve stones and large cobbles, their volume percentages should still be estimated visually. For soils with coarse fragments greater than 7.5 cm in diameter (medium sized cobbles) 8-10 L of soil should be sieved to estimate the percent coarse fragments. For soils with coarse fragments in the fine to medium gravel size (<4 cm) 2-4 L of soil should be sieved to estimate their percentages (Gee and Bauder 1986). Sieving is easier when the soils are moist to dry.

Once sieved, various methods can be used to estimate[1] coarse and fine fraction volumes. One method is to form adjacent "loaves" of the coarse and fine fractions with similar width and height. In this case, use the relative lengths of these "loaves" as an estimate of the percentage of each fraction. Alternatively, use a 2-4 L graduated plastic pitcher to estimate the volume of the gravel and fines directly. In either case, the coarse fraction volume is calculated as a percentage of the total soil volume (fine + coarse). If, as an example, the < 2 mm and >2 mm <7.4 mm particle loaves are each 1 L, record an estimate coarse fragment volume of 50%.

While sieves represent additional field gear, periodic calibration throughout the season will increase soil data collection accuracy and field staff confidence.

Figure 1. Comparison charts for visual estimation of coarse fragments. (Mitchell et al. 1993)



[1] "Estimate" is bolded to highlight the fact that this field technique provides only a rough approximation of coarse fragment (CF) volume, much like the visual estimate. The estimates from these two field techniques are often reported to the nearest 10% (Childs and Flint 1990). Other more accurate field techniques, e.g., water displacement (Childs and Flint 1990) are not operationally practical. For detailed studies, volume coarse fragment percentages are calculated by multiplying the mass coarse fragment percentage (dry mass CF/total soil dry mass) by the total soil bulk density and dividing by the coarse fragment particle density.

3.0 FINE FRACTION

The "fine" soil fraction is also divided into three major size groups:

- Sand: 2 - 0.05 mm,
- Silt: 0.05 - 0.002 mm, and
- Clay: <0.002 mm.

Sometimes the sand fraction is further subdivided into:
coarse (2 mm - 0.5 mm), medium (0.5-0.25 mm),
fine (0.25-0.1 mm) and very fine (0.1-0.05 mm) sand.
The proportions of the three major size groups are expressed as a percentage of the total fine fraction (i.e., %sand + %silt + %clay = %100). Their relative proportions define the ***soil textural class*** as given in Figure 2.

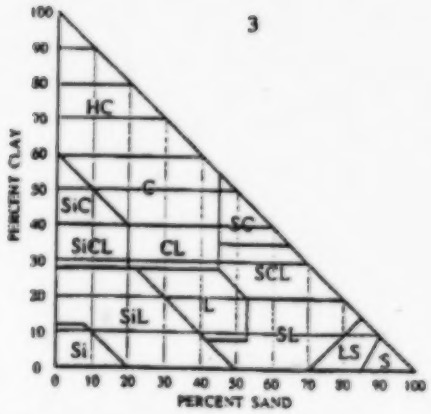


Figure 2 Soil Textural Triangle (Mitchell et al. 1993)

3.1 CALIBRATION: Fine Fraction

In the field, soil textural class is estimated by "hand texturing" -- how the soil "feels" and behaves to physical manipulation (e.g., rolling) at increasing water content. Correct hand texturing requires experience and periodic calibration. Field keys and flow charts to assist in estimating the soil textural class in the field include:

- FS 238 INF 81/6 Estimating Soil Texture in the Field (does not refer to vfsl);
- Appendix 8 Soil Texturing Key, *In* A Field Guide for Site Identification and Interpretation for the Nelson Forest Region (Braumandl and Curran 1992);
- Table 2 Hand Texturing, *In* PHSP Data Collection Handbook (Mitchell et al. 1993)
- Figure 3.2, *In* Describing Ecosystems in the Field (Luttmerding et al. 1990).

Calibration requires a "soil library" which includes a range of LOCAL soils with laboratory information on *particle size analysis*. This soil library should be used prior to the field season as a "warm up" quiz and during the field season as questions arise. Over time, soils which are difficult to hand texture should be sent to a laboratory for testing. Collect a sufficiently large sample (e.g., 4-5 L), so that the extra soil can be added to the local soils library. Using local soils is preferred since clay and mica minerals vary with the local geology and influence the "feel" of the soil (e.g., stickiness).

Lab Analyses

Laboratories determine soil texture using a *particle size analysis*. This analysis is offered by a number of laboratories in southern B.C. Two laboratory procedures are used to determine soil particle size distribution: sedimentation analysis and sieving. The two most common sedimentation analyses are the pipette and hydrometer methods. These methods are used to quantify particle sizes less than 0.05 mm (silt + clay). The pipette method is generally acknowledged to be more precise, although in most cases reasonable agreement is expected between the two methods. Sieving (wet or dry) is generally used to quantify particle sizes greater than 0.05 mm (sand), and is the method used to partition the sand into the various size classes (e.g., very fine sand). Dry sieving is also used to determine the percent of particle size classes greater than 2 mm.

Descriptions of the sedimentation and sieve procedures can be found in McKeague et al. (1978) or Gee and Bauder (1986). It is noted that most laboratories pretreat the soil to remove obvious cementing agents (e.g., carbonates, organic matter) prior to the sedimentation analysis. By definition, soil texture refers to the particle size distribution of the mineral component only. The sedimentation analyses are based on the principle that individual spherical particles of known density and size (radius) fall through a liquid at a constant velocity (Gee and Bauder 1986; Marshall and Holmes 1988). Cementing agents result in clusters of particles acting, or

"falling" as an individual particle, without a known density or shape. If cementing agents are not removed prior to the sedimentation analysis, the clay fraction will be underestimated.

The laboratory should receive a minimum of 500 g or 1.5 - 2^+ L of soil for analysis. To ensure comparability of results between laboratories over time, laboratories should be requested for the following information: method and reference; pretreatment(s) if any; % sand, % silt, % clay, % gravel, textural class; and breakdown of the sand fractions. Since several of the cementing agents may influence hand texturing (see below) consideration should be given to including % organic matter and % $CaCO_3$ in the laboratory analyses requested.

4.0 PARTICLE SIZE ANALYSIS (PSA) vs. HAND TEXTURES

To begin with, laboratory PSA results are expressed on a mass, or weight, basis while field assessments are expressed on a volume basis. For a given soil, the mineralogy and thus the particle density of the fine and coarse fractions are generally comparable. In most cases, there tends to be good agreement between the volume and mass estimates.

If proper care is taken in hand texturing, the hand texture and the laboratory-determined textural class should agree. The accuracy of laboratory PSA results is generally within +/- 4% sand, silt or clay. Where discrepancies in textural class arise, the following questions should be considered in resolving the differences:

- ***Did the samples come from the same field location?***
  If not, the difference may reflect spatial variability in the field. If the samples were collected from the same field location, the discrepancy may reflect variation within the sample itself. The sample may not have been sufficiently mixed (e.g., inclusion of two horizons with different textures). In either case further field investigation should be considered.

- ***Are fine and very fine sands dominant components of the sand fraction?***
  Very fine sands in particular can "feel" similar to silt. This is particularly noticeable if the fine sands are micaceous. A review of the laboratory partitioning of the sand sized fractions will assist in determining whether a high proportion of very fine/fine sand "swayed" the hand assessment towards a higher silt percentage. In this case, the management interpretations will be very similar whether the sample is called a silt loam or very fine/fine sandy loam (e.g., both have the same compaction hazard).

- ***What is the organic matter content?***
  High organic matter contents tend to reduce the stickiness of clay soils and make fine sand in particular feel silty (White 1987). If soil organic matter is routinely determined on the library soil samples, the field practitioner will develop an intuitive relationship between organic matter content and hand texture "feel". This information can then be used to consciously adjust the hand texture to take into account the influence of organic matter on the "feel" of the soil. For example, a soil organic matter content of 15-20% (based on visual cues and laboratory analysis) may increase the hand texture estimate of silt by as much as 5-10%. Soil organic matter contents greater than 15-20% are generally restricted to the wetter site moisture regimes. Soils with organic matter contents greater than 30% are classified as organic soils.

- ***Is mica a major component of the soil sample?***
  Mica is flat and does not settle in a liquid solution at the rate assumed for a spherical particle (an assumption of the sedimentation laboratory analyses). This may result in a slightly higher laboratory estimate of silt + clay . In most cases this is not a large error (i.e., <5% underestimation in sand). The laboratory will generally note this discrepancy.

- ***Are cementing agents present (e.g., carbonates)?***
  Finely divided $CaCO_3$ can give a silt-like feel to a soil (White 1987). Conversely, carbonates in the form of concretions, can increase the hand texture estimate of sand. Preliminary data collected in the Nelson Forest Region, however, suggests that even where the $CaCO_3$ content results in a moderate to strong HCl acid fizz, discrepancies between the hand texture and lab determined textural class are relatively uncommon. The possible exception is where both the soil texture and $CaCO_3$ are fine. Even in this situation, differences in soil textural class will probably only occur where the soil borders two textural classes. Additional data is being collected to further document the effect of $CaCO_3$ on hand texturing and soil behavior. In the meantime, where a discrepancy exists between the hand and lab texture class in the presence of a high $CaCO_3$ content, the finer textural class should be used to err on the side of caution (in terms of the potential for site degradation).

5.0 CITED REFERENCES

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Site Sensitivity Interpretations Working Group (SSIWG). 1993. Hazard assessment keys for evaluating site sensitivity to soil degrading processes - interior sites. LMH Field Guide Insert 8. B.C. Min. of For., Victoria, B.C.

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Appendix I SUPPLIERS[1]

A. LABORATORIES

Particle size analysis is offered at the following laboratories for $40-60 per sample. Shipping costs to return the sample is additional. Most laboratories are able to guarantee reasonable turn around times (i.e., 1 - 2 weeks). The following information should be requested: method (pipette, hydrometer); pretreatments (organic matter, carbonates, iron oxides); % sand, silt, clay, gravel, texture class; % coarse, medium, fine and very fine sand. Additional analyses for consideration include: % organic matter, % calcium carbonate, and pH.

- Griffin Laboratories Corp.: 1875 Spall Rd., Kelowna B.C. V1Y 4R2 PH: (604) 861-3234;
- Norwest Labs: 203 - 2077 Langley By Pass, Langley B.C. V3A 5E8 PH: (604) 530-4344;
- Pacific Soil Analysis Inc.: #5 11720 Voyageur Way, Richmond B.C. VX6 3G9 PH: (604) 273-8226;
- Soilcon Laboratories Ltd.: Unit 275 11780 River Rd., Richmond B.C. V6X 1Z7 PH: (604) 278-5535;

B. SIEVES

Brass, stainless steel and plastic sieves can be purchased. Sieve sizes (old US sieve no.) which may be of interest follow:

• 75 mm (3") • 2 mm (No. 10) • 1 mm (No.18) • 0.5 mm (No.35)
• 0.25 mm (No.60) • 0.10 mm (No.140) • 0.053 mm (No. 270).

Sieve dimensions and approximate 1993 costs (excluding shipping/taxes) for 2 mm sieve are as follows.

Sieve Type	*8" OD x 2" ht.*	*8" OD x 1" ht.*	*3" OD x 2" ht.*	*3" OD x 1" ht.*	*12" OD x 4" ht.*
Stainless Steel	$75-110	$75-110	$55-65	$55-65	
Brass	$55-85	$55-80	$42-55	$42-55	
Plastic					$120-160

Sieve suppliers include:

- Canada Wide Scientific Ltd., 1230 Old Innes Road Unit 414, Ottawa, Ontario K1B 3V3 PH: (613)741-6197 (1-800-267-3787);
- Canadian Forestry Equipment Ltd. (CFE), 17309 107 Ave, Alta. T5S 1E5 PH: (403)484-6687 (1-800-661-7959);
- CanLab Division Baxter Diagnostics Corporation, 11620 181[st] St., Edmonton, Alta. T5S 1M6 PH: (403) 453-3921 (1-800-661-7222);
- Fisher Scientific Ltd., P.O. Box 2149, Vancouver, B.C. V6B 3V1 PH: (604) 872-7641 (1-800-972-7479);
- Hoskin Scientific Ltd., 239 E 6[th] Ave., Vancouver, B.C. V5T 1J7 PH: (604) 872-7894 (1-800-663-3023).

The above suppliers may or may not carry all types of sieves. Hoskin Scientific Ltd. and CFE are the only suppliers of the small (3" OD) sieves, at this time. Further, some suppliers may require an account number. Collection trays are available for all sieves ($30-60). The larger sized sieves should be used for coarse fragment estimates, the smaller sized sieves will be useful for "sieving out" fine gravels prior to hand texturing.

3" x 2" and 8" x 2" sieves
(scale in inches)

C. SCREENS

2 mm (or #10 mesh) stainless steel screens (4' width x >1' length) can be purchased from:

- Western Canadian Screens Ltd., 669 Derwent Way, New Westminster, B.C. V3M 5P7 PH: (604) 520-5949 (1-800-663-7705);
- Power Screen of Canada Ltd., 31244 S. Fraser Way, Clearbrook B.C. PH: (604)852-9021.

For further information on any of the above, contact G.Davis (354-6707).

[1]This list of suppliers is not intended as an endorsement or approval by the Ministry of Forests, of any product or service to the exclusion of others that may be suitable.